Workers' Perceptions and Attitudes about coal-dust exposure and health hazards: Case of Bulawayo Power Station, Zimbabwe

UNIVERSITY
OF
JOHANNESBURG

A mini-dissertation submitted to the Faculty of Health Sciences, University of Johannesburg, in partial fulfilment of Masters of Public Health: Environmental Health

By

Lentsoe Noko

(Student Number: 217090541)

29 November 2019

Supervisor : ---------------------------------- ----------------------------

Mrs Martha Chadyiwa **Date**

29 November 2019

Co-supervisor : ---------------------------------- ----------------------------

Dr Tafadzwa Makonese **Date**

DECLARATION

I declare that this mini-dissertation is my unaided work. It is being submitted for the Degree of Master of Public Health; at the University of Johannesburg, Johannesburg. It has not been submitted before for any other degree at any other institution.

Signature of candidate

EXECUTIVE SUMMARY

Coal-dust exposure is a significant occupational health hazard in the coal processing sector. This exposure is associated with various occupational respiratory health problems among the working population, especially in developing countries. However, there is limited literature on workers' perceptions of coal-dust exposure and related health outcomes. The study aimed to establish the workers' perception of coal-dust exposure and health hazards at a coal-fired power station. A descriptive cross-sectional design was employed and used stratified sampling to select 152 workers from 245 power generation process workers. The data were collected through the use of a structured interviewer-administered questionnaire. Data were analysed using the Statistical Package for the Social Science (SPSS) Version 25. The study showed that most respondents had knowledge about the sources (81%) and route (93.4%) of coal-dust exposure; the frequency (57.9%) and duration of exposure (48%) that could lead to the development of respiratory or breathing problems (57.9%); health problems (74.3%) and prevention methods (84.2%). However, most of the respondents (82.2%) were unaware of safe coal dust concentration levels. Majority (94.7%) perceived that workers were exposed to coal-dust, it was the primary health hazard (67%) and were at risk of developing respiratory problems (76.3%). Just under half (49%) perceived that coal-dust exposure causes tuberculosis. Most respondents did not perceive the risk of transmission of coal-induced breathing problems between workers (79%) and to their children (67.8%). Less than half (40.8%) of respondents reported that coal-induced breathing problems were incurable through the use of medicine. Majority of the respondents (77%) perceived that workers can be protected from coal-dust exposure. Therefore, workers had good knowledge of coal-dust hazards; they perceived it as a major hazard and were at risk of developing respiratory problems. The workers' perception was the same regardless of their length of work. Hence they may adopt healthy behaviours and safe practices to reduce coal-dust exposure. Reinforce safe behaviours through adoption of workplace policies, procedures and health promotion programs that encourage participation in reducing coal-dust was recommended.

DEDICATION

This mini-dissertation is dedicated to my beautiful and precious wife, Asaina Noko, for all the support and motivation throughout this study.

Second, I dedicate this study to my children, Thapelo and Joan Karabo Noko. You are my motivation to work harder.

ACKNOWLEDGEMENTS

I would like to acknowledge and convey my sincere appreciation and gratitude to the following individuals and institutions who rendered their assistance throughout this study:

- I give Glory and Honour to God, for granting me the gift of life and the opportunity to conduct this study.
- My Supervisor, Mrs Martha Chadyiwa, thank you for the patience, time and expert guidance throughout the study.
- My Co-Supervisor, Dr Tafadzwa Makonese, thank you for the insightful contributions made towards the success of the study.
- University of Johannesburg Faculty of Health Sciences and Department of Environmental Health for all the support services granted throughout the study programme.
- University of Johannesburg Statkon Department especially Juliana van Staden for her assistance in analysing the data.
- Zimbabwe Power Company, for giving me permission to conduct the study at Bulawayo Power Station.
- Bulawayo Power Station management led by Mr T. Chuma for facilitating the conduction of this study and its workers for consenting to be part of the study.

TABLE OF CONTENTS:

LIST OF TABLES

LIST OF FIGURES

LIST OF ACRONYMS

ACGIH	American Conference of Government Industrial Hygienist
CWP	Coal Workers' Pneumoconiosis
COPD	Cumulative Obstructive Pulmonary Diseases
DOL	Department of Labour
HSE	Health and Safety Executive
IEC	Information Education and Communication
ILO	International Labour Organisation
NIOSH	National Institute of Occupational Safety and Health
OEL	Occupational Exposure Limits
OHS	Occupational Health and Safety
WHO	World Health Organization
PM	Particulate Matter
REL	Recommended Exposure Limit
SPSS	Statistical Package for Social Sciences
TLV	Threshold Limit Value

CHAPTER 1: INTRODUCTION AND BACKGROUND

1.1 BACKGROUND

"Coal is an organic sedimentary rock which is naturally combustible material consisting primarily of carbon and contains low percentage of other materials such as compounds of nitrogen and sulfur'' (Speight, 2016; 1). It is a fossil fuel which is formed through a geographical process that takes place over millions of years. Buried plant material and organic matter in the presence of high temperature and pressure are converted into peat, lignite, sub-bituminous coal, bituminous coal and subsequently anthracite coal (Riazi & Gupta, 2015).

Coal is mined from the ground through two methods, opencast and underground (Riazi & Gupta, 2015). The opencast or open pit is surface mining used to extract coal at a depth not exceeding 30 meters. It involves removing the overburden of rock and soil (top layer) by explosives; the exposed coal seam is drilled, fractured and systematically mined in strips (Speight, 2016). Underground mining is used to extract coal deeper than 30 meters; it is accessed through cutting through the overburden rock at an angle to get to the coal seam. A continuous miner is used to mine, creating pillars which remain supporting the roof. Roof bolts are used on the ceiling to stabilize the roof of the mine. Coal is loaded into a shuttle car and carried by a conveyor belt to the surface. The other underground mining method involves full extraction of the coal seam through the use of mechanical shearers, such that there is no pillar left to support the roof (Speight, 2016).

The largest coal producers in the world are China, United States of America, India, Australian and Indonesia; with around seventy countries having recoverable coal reserves. In Southern Africa, South Africa constitutes 3.5% of the world total proved recoverable coal reserves, with 30 156 million tonnes of anthracite and bituminous coal at the end of 2008 to 2011. Zimbabwe constitutes 0.1% of the world total recoverable coal reserves, with 502 million tonnes of anthracite and bituminous coal (World Energy Council, 2013).

Globally, coal is used for various purposes, such as electricity generation, transportation, and the manufacturing of steel, cement and aluminium. Approximately

41% of global electricity is currently fuelled by coal-fired power plants (World Coal Association, 2018). Electricity is used as a source of energy for lighting and heating in domestic and industrial areas. Coal is used in 70% of steel production; two hundred kilograms of coal is used to produce one tonne of cement, and 50% of the energy used to produce aluminium comes from coal (World Coal Association, 2018).

Thermal power generation uses coal that is crushed and pulverised into coal dust. Coal dust is a complex and heterogeneous mixture containing carbon, crystal silica and other trace elements such as boron, cadmium, nickel, iron, antimony, lead and zinc (National Institute of Occupational Safety and Health, 2015). Coal-dust exposure is associated with lung diseases, such as coal workers' pneumoconiosis, silicosis, dust-related fibrosis and mixed-dust pneumoconiosis (Beer *et al*., 2016). Coal dust concentration, duration of exposure and coal characteristics, such as coal rank, quartz and iron content, increase the likelihood of developing lung diseases (Beer *et al*., 2016).

Respiratory health effects found among workers at a thermal power plant include shortness of breath, asthma, emphysema, chronic bronchitis, lung cancer, pneumonia, tuberculosis, wheezing, and chest pain and cough (Kumar *et al*., 2015). Studies in South Africa indicated that the risk of coal workers' pneumoconiosis depends on the chemical, carbon and iron content of coal. Thus, the incidence of coal workers pneumoconiosis at a given coal dust concentration was found to vary in different regions of the country (Utembe *et al*., 2015).

Human factors, such as behaviour, are known to be influenced by individuals' perception and attitude (Cooper, 2011). Thus, workers with a low safety perception are more likely to take shortcuts or engage in risk behaviours, which would result in injury or increase their exposure to health hazards and risk (O'Toole & Nalbone, 2011). A study of safety culture at underground coal mines showed that safety was considered to be the highest priority by 10% of supervisors and workers when compared with wages, work organisation, job security and human relations (Martyka & Lebecki, 2014). However, a more positive evaluation of formal standards was found in supervisors, compared to workers (Martyka & Lebecki, 2014).

Previous studies on employee's attitude to work safety in Polish coal mining companies showed a difference in attitude regarding compliance with Occupational Health and Safety (OHS) regulations and safety perceptions between employees with a predominance of z-traits and those with the least (Tobor-Osadnik *et al*., 2017). Approximately 100% of respondents with strong intensity felt they were directly responsible for compliance with OHS regulations, compared to 25% with least the intensity, who felt they were not directly responsible. More than half of respondents from both groups had an opinion that compliance with OHS regulations makes their work more difficult and would breach OHS regulations to make work easier (Tobor-Osadnik *et al*., 2017).

A safety attitude study conducted in the Chinese coal mining industry revealed that emergence of safety into overall management, safety training and safety department recognition were rated very high by managers (Zhang *et al*., 2016). The prevention of accidents, economic benefits of safety, safety awareness, and safety management systems, cognition of safety performance and human resources, and emergency capabilities were rated high. Little attention was given to the perceived importance of safety, responsibility of work safety systems, safety investment, safety regulation, managers' safety responsibility, and the mastery of safety methods by the managers (Zhang *et al*., 2016). An overall improvement of managers' perception of safety issues was noted in 2014 compared to 2009. Nine safety concepts were significantly higher in 2014 than in 2009, while four decreased significantly (Zhang *et al*., 2016).

A knowledge, attitude and perception study regarding occupational safety at Shangla District showed that eight out of 101 participants (7.9%) were aware of coal mine health hazards. Seventy-five (74.2%) were working without protective equipment. Seventy-five percent of participants reported that they were currently disabled and retired as a result of respiratory symptoms (Ashraf *et al.,* 2005). About 19% had been absent from work for more than three months as a result of ill health. Twenty-one were willing to send their children to work in coal mines (Ashraf *et al*., 2005). Knowledge, attitude and perception studies on safety have been conducted at different collieries, however this study aimed at establishing workers' perceptions and attitudes regarding coal-dust exposure and health hazards at a coal-fired power station.

1.2 PROBLEM STATEMENT

The majority of the previous similar studies were conducted outside workplaces for community members exposed to either indoor or outdoor air pollution that may lead to certain public health outcomes. A study of the health risk perception of residents located around a smelter plant in Zimbabwe identified the smelter as the source of health problems that presented adverse health risks and respondents perceived that the air quality was poor (Gwimbi, 2017). The limited studies conducted in workplaces have focused on other workplace exposure and hazards. A knowledge, attitude and perception study of occupational hazards and safety practices among Nigerian health care workers found that there was a high level of knowledge of occupational hazards and belief that they were at risk, and the risk perception was found to be high (Aluko *et al*., 2016). Therefore, there is limited literature on perception studies, especially in workplaces such as factories and mines.

Extensive literature has revealed that exposure to coal dust is associated with respiratory health outcomes, such as Cumulative Obstructive Pulmonary Disease (COPD), coal workers' pneumoconiosis (CWP) and other symptoms, such as shortness of breath (Laney & Weissman, 2014). The global prevalence of COPD was 251 million in 2016, accounting for more than 90% of deaths in low and middle-income countries (WHO, 2017). The CWP prevalence in China was 10 821, between 2001 and 2011 (Mo *et al*., 2014). The incidence of CWP in the United Kingdom gradually increased between 2005 and 2007 from 200 to 300 per year, with 140 deaths (Health and Safety Executive, 2016). In Zimbabwe, it increased from three confirmed cases in 2009 to 29 in 2013, with five cases being recorded at two coal-fired power stations (Zimbabwe Annual Statistical Report, 2009 - 2013). These statistics reveal the severity of coal-dust exposure both at global and localised scale; thus workers' perception and attitude of such risk exposure were explored.

Previous perception studies in workplaces with coal-dust exposure focused on occupational health and safety issues such as safety procedures, safety regulations, protective equipment and safety hazards, which result in occupational accidents and injuries. Thus, limited literature focused on coal-dust exposure and health hazards. Coal miner's knowledge, attitude and perception study on occupational safety at

Shangla District reported that the majority were unaware of occupational safety and there was no use of protective equipment (Ashraf *et al*., 2005). Therefore, the knowledge gap explored was on the workers' perception of and attitude to coal-dust exposure, focusing on the routes of exposure, the risk factors, health outcomes and control. Furthermore, these previous studies were conducted at coal mines, while this study was conducted at a coal-fired power station.

1.3 AIM

The study aims to establish the workers' perception and attitudes regarding coal-dust exposure and health hazards.

1.4 OBJECTIVES OF THE STUDY

- To determine workers' knowledge about coal dust health hazards

- To assess the workers' perception and attitudes towards adverse health effects of coal dust

- To establish the relationship between workers' perception of coal-dust exposure and length of work

1.5 RATIONALE FOR THE STUDY

Most knowledge, attitude and perception studies conducted in collieries for example in Poland (Tobor-Osadnik *et al.,* 2017) and China (Zhang *et al*., 2016), have focused on general safety awareness and compliance. However, there has been limited such studies on coal-dust exposure. The study intended to bring to light workers' awareness, beliefs and opinions on the risk of such exposure. The study results would aid in determining the workers' behaviour modification necessary to reduce coal-dust exposure. The analysis of workers' perceptions is very imperative as a proactive management tool in designing effective safety and health policies, both at corporate and national levels (Gyekye, 2006). The workers attitudes, perception, competences, values, patterns of behaviour; quality and style of safety management contribute to the overall safety culture of an organisation (Martyka & Lebecki, 2015). Therefore, the study contributes to bridging the gap in the literature and contributes to the body of knowledge of workers' perception and attitude of coal-dust exposure and health hazards.

1.6 OUTLINE OF RESEARCH

Chapter 1 gives an overview of the study by introducing and giving a background to coal formation, its uses, adverse health effects caused by exposure, workers' perceptions and attitude of exposure. The statement of the problem addresses the knowledge gaps that exist and warrants the study to be undertaken. The study aims to establish the workers' perception and attitudes regarding coal-dust exposure and health hazards. The study rationale was to eliminate the literature gap in the subject matter.

Chapter 2 reviews literature related to coal-dust exposure, risk factors, adverse health outcomes and control. It also explores studies on knowledge, attitude and perception of workers and community members who were exposed to different environmental hazards.

Chapter 3 presents the methods that were used to conduct the study. A quantitative and descriptive cross-sectional survey was conducted at Bulawayo Power Station in Zimbabwe, where data were collected from power generation workers through the use of an interview questionnaire, and ethical issues were considered.

Chapter 4 presents the results and discusses the research key findings. The research findings were on the socio-demographic characteristics of the respondents. The main findings were on the workers' knowledge of coal-dust health hazards; their perception of adverse health effects and its relationship with their work experience.

Chapter 5 concludes by giving a summary of the key findings for each objective and the final message of the study. It gives recommendations and suggests future research that may be undertaken based on the results and findings of the study.

CHAPTER 2: LITERATURE REVIEW

2.1 INTRODUCTION

This chapter focuses on the review of literature on the description of coal and the process of coal-fired power generation. It also explores the literature on coal-dust concentration levels and the frequency and duration of coal-dust exposure that could lead to the development of occupational respiratory conditions. Furthermore it enquired respiratory health problem associated with coal-dust exposure and its control. Lastly it probed the knowledge, attitude and perception studies of workers and community members who were exposed to different environmental hazards. The purpose of the chapter was to explore the current body of knowledge concerning the subject matter, benchmark with similar and relevant studies and identify knowledge gaps that warranted this study to be undertaken.

2.2 DESCRIPTION OF COAL

Coal is a carbonaceous black sedimentary rock, which contains carbon, hydrogen, oxygen, nitrogen, lesser amounts of sulphur and other trace elements. These trace elements include arsenic, mercury, cadmium and zinc and have an affinity for sulphur and so they attach to the coal fuel (Kraushaan & Ristinen, 2015). Coal dust contains calcium, magnesium, aluminium, iron and has up to 10% of free crystalline silica quartz, which is the most hazardous substance (Miller *et al*., 2015).

There are four classes of coal, namely, lignite, sub-bituminous, bituminous and anthracite (Affolter & Hatch, 2015). Lignite or brown coal is the softest lowest rank of coal with the least amount of carbon. Sub-bituminous coal has properties that range between lignite and those of bituminous coal. Bituminous and anthracite coal are used in manufacturing coke and an essential fuel for electricity generation. Anthracite is the highest ranked and hardest coal, which is glossy black and contains the most carbon and energy content (Affolter & Hatch, 2015). Studies indicate that the risk of Coal Workers' Pneumoconiosis (CWP) depends on the carbon content of coal and anthracite contains more carbon than other types (Utembe *et al*., 2015).

2.3 COAL-FIRED POWER GENERATION PROCESS

The main raw materials for coal-fired power generation process are coal, water and air, with coal used as a fuel. Coal is delivered to the storage plant of the power station (coal yard) by either road or rail transportation (Sarkar, 2015). The coal is conveyed to the coal handling plant (coal plant) for pulverisation into a very fine powder by ball mills or rotating drums. Pulverisation of coal is done to promote rapid combustion without using a large quantity of air. The pulverized coal is air-blown into the boiler furnace, to ignite rapidly such that the complete combustion of coal takes place. A boiler furnace is a closed vessel which converts water into steam, under pressure (Kumar, 2016).

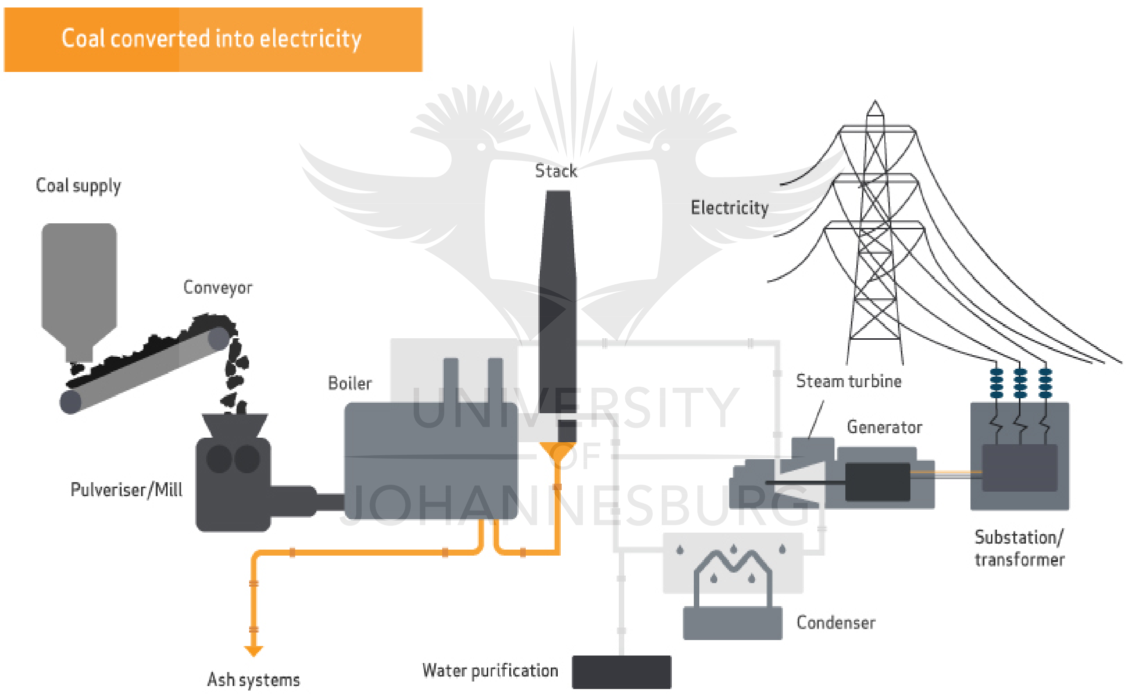

Fig 2.1: Typical process flow diagram for a coal-fired power station (Iashin, 2018).

The water from the water purification plant is fed to the economiser before being supplied to the boiler. The economiser extracts part of the heat from the flue gases coming out of the boiler to heat and increase the feed water temperature before it enters the steam boiler (Hegde, 2015). An air pre-heater which draws its heat from the flue gases raises the temperature of the air used for coal burning. Thus, the heat of combustion inside the steam boiler at high temperature and pressure is used to convert the feed water into steam. The steam produced in the boiler is dried and superheated by passing it through a superheater (Sarkar, 2015).

The superheated and dry steam is fed into the steam turbine through the main valves. A steam turbine is a machine or shaft which rotates steadily by impact or reaction of steam upon blades of a wheel. It consists of a series of steam turbines interconnected to each other and a generator on a common shaft (Kumar, 2016). The steam containing heat energy passes over the turbine blades and is converted into mechanical energy. The generator or alternator that is coupled to the steam turbine converts mechanical energy into electrical energy, which is delivered as electrical output through a transformer, circuit breakers and isolators (Hegde, 2015).

The exhausted steam from the turbine, after giving heat energy, moves to the condenser, where it condenses into liquid using cold water circulation (Hegde, 2015). Water drawn from another different source is circulated through the condenser. The heat from the exhausted steam is taken up by the circulating water and becomes hot. The hot water from the condenser is discharged and passes on to the cooling tower, where it is cooled for use. Thus, the condensate is also used as feed water to the boiler (Sarkar, 2015).

2.4 ADVERSE HEALTH OUTCOMES OF COAL-DUST EXPOSURE

Inhalation of coal dust causes occupational respiratory diseases and conditions such as coal workers' pneumoconiosis (CWP), chronic obstructive pulmonary disease (COPD), silicosis and dust-related diffuse fibrosis. Mixed-dust pneumoconiosis may develop as a result of combined exposure to coal and crystalline silica (quartz) dust (Laney & Weissman, 2014). Coal workers pneumoconiosis is interstitial lung disease caused by the inhalation of coal dust and the lung tissue's reaction to the dust. Chronic Obstructive Pulmonary Disease (COPD) is a group of diseases such as chronic bronchitis, emphysema and occupational asthma which cause airflow blockages resulting in breathing-related problems (National Institute of Occupational Safety and Health, 2015).

Globally, the World Health Organization (2017) identifies COPD as the fifth environmental risk cause of death, with 12% of cases due to workplace exposure and air pollution; and 30% from household air pollution. Globally, COPD has resulted in 353 000 deaths, with sixteen thousand deaths in Africa (WHO, 2017). Annually in the United Kingdom, there are at least 40 new cases of silicosis with 20% of reported cases from mining and quarrying and at least 10 deaths (HSE, 2016). The prevalence rate of dust-related diffuse fibrosis in United States per 100 000 were 3.8 at 18 to 34 years; 4.9 at 35 to 44; 23.3 at 45 to 54; 62.8 at 55 to 64; 148.5 at 65 to 74 and 276.9 at 75 or more years (Laney & Weissman, 2014).

A systematic review and meta-analysis of occupational exposure and risk of COPD revealed that low exposure to mineral dust such as coal had a significant association with the risk of COPD. An increased association between low and high exposure to mineral dust and the risk of chronic bronchitis was noted (Alif *et al*., 2016). The results of a study at a Colombian underground coal mine showed that there was a significant association between pneumoconiosis and severe exposure to coal dust. Thus, the prevalence of pneumoconiosis was high (33.8%) (Varona *et al*., 2018). In addition, a significant association was noted between work exposures of 25 years or more and working in a medium size enterprise and pneumoconiosis (Varona *et al*., 2018).

2.5 RISK FACTORS OF THE DEVELOPMENT OF OCCUPATIONAL RESPIRATORY DISEASES

A study on respirable dust and quartz exposure at coal power stations in Mpumalanga province, South Africa from 2012 to 2015, showed that the highest mean respirable quartz exposure was 0.036 mg/m^3 and a median value of 0.03 mg/m^3 which exceeded the American Conference of Government Industrial Hygienist (ACGIH) Threshold Limit Values (TLV) of 0.025 mg/m^3 (Mabanga, 2017). Threshold Limit Value or Occupational Exposure Limit are airborne concentration of dust, which are believed that workers may be repeatedly exposed over their working time without suffering harmful consequences (ACGIH, 2014). About 7.3% (n=55) of all occupations were exposed to quartz concentration equal to or exceeding the Department of Labour (DoL) Occupational Exposure Limit (OEL) of 0.1 mg/m^3, while 29.4% (n=221) exceeded the ACGIH TLV. Four and half percent (n=35) were exposed to respirable dust concentration equal to or exceeding the DoL OEL. Approximately 95.4% (n=721) of all occupations were below the DoL OEL (Mabanga, 2017).

A study on pneumoconiosis and the quartz content of respirable coal dust revealed that coal-dust levels in most of the coal mines were higher than the permissible standards (Erol *et al*., 2013). The mean dust concentration was between 1.6 and 14.5 mg/m^3, with the quartz content ranging between 0.7 to 10.4 percent. Thus, the study concluded that the rates of CWP increases as the respirable dust levels and the quartz content increases (Erol *et al*., 2013).

A study conducted in Colombia, to establish the relationship between coal-dust levels and pneumoconiosis found that there was an association between a radiologic diagnosis of pneumoconiosis and a medium risk level of carbon-dust exposure, medium size companies, smoking history of more than a year and length of work greater than 25 years (Rey *et al*., 2015).

The results of a study carried out in Hubei Province China between 2008 and 2013 revealed that a total of 3665 new pneumoconiosis cases were reported. Approximately 97.2% of cases were for coal workers' pneumoconiosis and silicosis, while 6.6% were combined pneumoconiosis and tuberculosis. These incidences of tuberculosis were prevalent among workers with silicosis. About 33.3% of cases were for workers with a duration of exposure of fewer than ten years (Xia *et al*., 2014).

2.6 MANAGEMENT OF COAL-DUST EXPOSURE

The measures to control coal-dust exposure that could lead to the development of occupational respiratory diseases are the adherence to appropriate occupational exposure limits standards and guidelines by employers (Zosky *et al*., 2016). The alignment of national monitoring standards on occupational dust exposure limits with international ones. Another measure is the implementation of a comprehensive screening programme for monitoring coal workers' health for purposes of early-stage identification of respiratory diseases and to prevent progression. Comprehensive screening programme should be in line with ILO guidelines, which include the completion of a questionnaire, medical imaging, lung function testing and diffusion capacity measurement (Zosky *et al*., 2016).

Primary prevention intervention measures to control the prevalence of CWP in coal mining includes the use of technology to reduce inhalable and respirable dust exposure (Ayaaba *et al*., 2017). Other measures included adherence to mining laws and regulations, surveillance, risk assessments, direct dust-control measures and compensation. Public strategies such as combining different health measures, for example workers training on safety measures, were effective in preventing CWP (Ayaaba *et al*., 2017).

2.7 KNOWLEDGE, ATTITUDE AND PERCEPTION EXPOSURE STUDIES

According to the Cambridge English dictionary, "knowledge is an awareness, understanding of or information about a subject that you get by experience or study either known by one person or by people generally" (Cambridge Dictionary, 2019; 1). Knowledge can be acquired through discovery, which is experience; and learning, which includes education and training. Safety and health training play an important role in modifying workers' behaviour Thus workplace training should include knowledge of health and safety risks, proper use of protective equipment, and compliance with procedures, awareness of the benefits of safe behaviours and general awareness (Cooper, 2001).

"Attitude can be defined as a set of emotions, beliefs, and behaviours toward a particular object, person, idea, or event built up as a result of experience, social factors and learning" (Cherry, 2018:1). They comprise of a set of predetermined responses that are developed through individual evaluations of a particular subject, idea, object or event. These evaluations and responses can be positive, negative, neutral or even mixed, and may change over time (Cherry, 2018). Attitude towards a particular subject can be influenced by thoughts and beliefs which is cognitive; behaviour and emotional reaction such as fear or anxiety, which is affective (Cherry, 2018).

"Perception is awareness of something, the way in which it is understood, regarded or interpreted, whether one's thoughts and feelings or social surrounding" (Hatfield, 2011:11202). The basic aspect of perception is usually limited to an individual sensory response to a stimulus. Perception is related to a certain individual's actions. For example, an object may trigger a certain reflex reaction in an individual, which will lead to the formation of an association between the object and action. The action an individual undertakes will be as a result of their perceived consequences (Hatfield, 2011). Thus, voluntary stimulus-response reactions are formed because of perceived associations. Therefore perception can determine the likelihood of behaviours to certain objects and risks (Ivers *et al*., 2009).

Knowledge, attitude and perception of individuals influence their behaviour (Cooper, 2001). Behavioural change theories and models on individual, interpersonal behaviour and community/ group intervention have been developed to explain the reason people engage in harmful activities; to develop and evaluate specific behaviour change interventions (Naidoo & Wills, 2009). The Health Belief Model predicts that an individual is likely to adopt a certain behaviour if they believe in a personal threat of an illness or disease and in the effectiveness of the recommended health behaviour or action (Scriven, 2010). Therefore adequate knowledge, correct attitudes and perceptions of coal-dust exposure and health hazards will result in healthy behaviours among workers.

Studies on workers' knowledge, attitude and perception regarding safety and health has been conducted in different industries. Eight out of 101 participants (7.9%) were aware of coal mine health hazards in a study of knowledge, attitude and perception of coal miners regarding occupational safety (Ashraf *et al*., 2005). Seventy-five (74.2%) were working without protective equipment. Seventy-five percent of participants reported that they were currently disabled and retired as a result of respiratory symptoms, and 19% had been absent from work for more than three months as a result of ill health (Ashraf *et al*., 2005). Thus, coal miners had no regard for occupational safety issues.

Employee perception of OHS standards in the steel industry were found to be satisfactory (Mojapelo *et al*., 2016). The results indicated that workers were provided with adequate training and information on OHS, which included safety induction and the proper use of personal protective equipment. Workers were aware of hazards found in their respective workplaces. They followed safety procedures and exhibited safe behaviours. Employers were encouraging workers to report OHS issues and work environments were meeting the prescribed OHS standards (Mojapelo *et al*., 2016).

The majority of workers (43%) in food industries in Zimbabwe had a neutral perception about their work conditions being safe (Marambanyika & Sadrake, 2013). Thirty-four percent of workers held the view that the safety of their work conditions was good and 6% very good, while 11% poor and 1% very poor. Fifty-three percent of workers were unaware of occupational safety and health legislation that govern their work, 4% were neutral, and 43% were aware. Thus, 43% were aware of the National Social Security Act, 37% of the factories and Works Act, 10% of the Pneumoconiosis Act, 3% of the Labour Act, and 7% were aware of all the safety and health legislation (Marambanyika & Sadrake, 2013).

A behavioural study on worker's attitude to wearing hearing protection and how these might be changed reported high levels of risk awareness, average knowledge and negative attitudes (myths and misunderstanding) about noise exposure (Hughson *et al*., 2002). Interventions which were instituted were providing suitable basic noise awareness training, provision of alternative hearing protectors, and basic feedback and communication coaching for management. A follow-up survey after the interventions showed that there were positive results with increased hazard awareness and use of hearing protection (Hughson *et al*., 2002).

A knowledge, attitude and beliefs study about the health hazards of exposure to biomass smoke in Nigeria revealed that most of the commercial food vendors were unaware that biomass smoke exposure was harmful to their health (Nwankwo *et al*., 2018). The majority were unconcerned the health effects of biomass fumes to them. Less than half believed that the smoke of biomass was harmful to their health (Nwankwo *et al*., 2018). Good knowledge of the health effects of biomass smoke exposure was associated with having post-primary education, being male and single. Positive attitudes towards preventing exposure were associated with a good knowledge of adverse health effects and being female (Nwankwo *et al*., 2018).

A study to investigate respiratory disorders among gold miners in Ghana found that there was a significant association between age, educational background, marital status and drinking alcohol with respiratory disorders (Ayaaba *et al*., 2017). Gold miners perceived that dust exposure (64.1%) was the major cause of work-related illness in the organisation. Thus coughing (35.4%) was the most cited respiratory symptom. Other perceived causes of occupational illness were contact with other chemicals (57.9%), pollution (18.6%), personal hygiene (3.9%) and other causes (0.5%; Ayaaba *et al*., 2017).

Approximately 61.9% of construction workers had a good knowledge of hazards in a study conducted in Nigeria (Oluwafemi *et al*., 2017). Dust hazard was identified by 71.7%; 64.5% identified manual handling; 56.4% identified excessive noise, and extreme heat was identified by 51.7%. Regarding the use of protective equipment, 19.8% reported they wore gloves, 16.9% wore helmets, 10% face masks and 10.2% wore earplugs. Of the surveyed workers, 53.8% had a poor attitude to occupational safety measures, while 46.2% had a good attitude. Poor safety measures were reported by 85.7% and 14.3% reported good safety practices (Oluwafemi *et al*., 2017).

A study of the management of wood-dust exposure in small and medium construction and manufacturing enterprises reported that there was poor awareness of the importance of preventing ill health (HSE, 2014). There was an underestimation of respiratory health risk. Negative attitudes were noted among management towards occupational health and safety, and towards the implementation of risk controls. Risk control information was being sought from external sources (HSE, 2014).

A study of safety practices and the knowledge of construction workers of the hazards associated with working on a road construction site in Edo, Nigeria showed that most workers had a good knowledge of road construction site hazards (Stella & Okeoghene, 2017). There was no statistical significance between workers who had worked for more than five years and their perception or knowledge of construction hazards (Stella & Okeoghene, 2017). However, a significant association was found between age, socio-economic status and duration of work, with having the knowledge and appropriate attitudes among textile workers in Pakistan (Khoso & Nafee, 2015).

A relative acceptance of health, safety and environment (HSE) management and safety climate was shown in a survey at a construction site in Iran (Mobaraki *et al*., 2017). A significant relationship was reported between the mean scores of safety climate, job groups and HSE management systems with education and experience. There was no association of workers' safety perception and age, work experience and education. Top management was responsible for the creation of a safety climate (Mobaraki *et al*., 2017).

A study of perception and attitude towards work-related ill health and the use of dust masks among crushers revealed that 94% viewed their work as the source of ill health (Uwakwe *et al*., 2015). The majority of the respondents (96.3%) perceived dust as their major hazard. About 9.5% associated their work to silicosis and 96.3% associated it with their cough, with 55.6% believing that ill health arising from work could be controlled. Approximately 98.1% believed that dust masks were useful, 75.9% that they were necessary and 79.6% respondents believed that they could prevent respiratory diseases; hence they (96.3%) should be worn (Uwakwe *et al*., 2015).

Vocational students were unaware of the illnesses (long latency diseases) that could result from exposure to respiratory risk substances, such as dust and fumes (HSE, 2010). However, there was a general view that asbestos dust that was inhaled was unable to leave the body and could result in death. Little knowledge of the measures of protection against occupational hazards was reported, as there were low levels of awareness of respiratory protective equipment among plumbers, electricians and construction students (HSE, 2010).

Almost half of the workers (n=182, 48.9%) had a good knowledge regarding respiratory symptoms among textile workers in Pakistan (Khoso & Nafee, 2015). About 302 (81%) had an appropriate attitude towards cotton-dust exposure. Lungs were cited as the organ affected by the harmful effects of cotton dust by 85.2% of the workers, while 10% were unaware of any harmful effects of cotton dust. Regarding protective measures, 60.8% wore face masks, 17.7% used brown sugar, 7.8% used individual measures, and 10.8% were unaware of any protective measure. About 5.1% of workers perceived that it was impossible to protect against cotton dust, and 7.3% viewed changing or quitting their work as an option (Khoso & Nafee, 2015).

A study of OHS problems in Zimbabwe’s wood processing industries revealed that workers were aware of hazards they were exposed to, which included wood dust, noise, heat and heavy lifting (Jerie, 2012). There was a perception that sawdust extractors were inefficient as workers were still inhaling sawdust in the air. These lack of hazard controls at source were perceived to lead to worker exposure to dust and noise. In conclusion, wood working industries perceived occupational health and safety as a less urgent priority (Jerie, 2012).

A risk perception study of dust and its impact among communities living in a mining area of the Witwatersrand, South Africa showed that all participants acknowledged that dust in the air was noticeable where they lived (Wright *et al*., 2014). Dust was a nuisance that caused health problems and contaminates water. Mine dumps (55.6%) were identified as the major source of dust, with other sources being sandblasting (22.2%), coal yards (11.1%) and the dry season (11.15). Closing windows, doors and vents; planting trees; watering and paving yards were given as coping mechanisms against dust exposure. Solutions proposed were for the government to search for former abandoned mine dump owners to rehabilitate the area, provide medical assistance for ill health caused by mine dust exposure and relocate their homes (Wright *et al*., 2014).

Studies on knowledge, attitude and perception towards occupational health and safety have been conducted in different workplaces such as mining, manufacturing and food industries. These studies included exposures to different physical agents such as noise and different types of dusts, however there has been no studies conducted on coal-dust exposure in a coal-fired power station. Intervention tools such as behaviour-based safety can modify perception and attitudes among workers (Cooper, 2001). It involves training and awareness sessions aimed at changing unsafe behaviours to safe ones (Jasiulewicz-Kaczmarek *et al*., 2015). Industries in Poland have implemented these interventions, which have resulted in the identification of risk behaviours and attitudes, improved communication and increased safety awareness (Jasiulewicz-Kaczmarek *et al*., 2015).

CHAPTER 3: RESEARCH DESIGN AND METHODOLOGY

3.1 INTRODUCTION

The purpose of the study is to establish the workers' perception of coal-dust exposure and health hazards. Therefore, this chapter discusses the methodology that the researcher undertook in an effort to fulfil the aim of the study. The chapter explains the research approach, study design, data collection and analysis. Under the heading of the study participants, the researcher considered the research area, study population, sampling criteria, inclusion and exclusion criteria, and ethical considerations.

3.2 RESEARCH APPROACH

The researcher used the quantitative approach as the data collected was numerical. The numerical data collected and analysed included socio-demographic data, such as age, gender and length of work; respondents' knowledge about coal-dust hazards; and their attitudes and beliefs towards adverse health effects of coal dust, which was categorised.

3.3 STUDY DESIGN

The research study used a descriptive cross-sectional design, as it assesses perceptions on exposure, outcomes and other population attributes simultaneously in a well-characterised population at a given point in time. Therefore, the study assessed population attributes, such as socio-demographic attributes and other attributes, such as workers' knowledge about coal-dust health hazards and their attitudes and beliefs towards the adverse health effects of coal dust, simultaneously.

3.4 RESEARCH AREA

The study was conducted at the Bulawayo Power Station, in Bulawayo, Zimbabwe. Bulawayo is the second largest city in Zimbabwe, after Harare, the capital. It is located south-west area of the country with an area of 1706.8 km^2 and a population of 653 337 (Zimbabwe National Statistics Agency, 2014). Zimbabwe has five power-generation plants, which include four coal-fired power stations, namely, Hwange, Bulawayo, Harare and Munyati; and a hydro-electrical power plant in Kariba South. Hwange has an installed capacity of generating 920 Megawatt (MW) of power, Harare has 60 MW, while Munyati has 100 MW and Kariba South a capacity of 750 MW. The Bulawayo power station has an installed capacity of 120 MW; it is currently generating 90 MW and is connected to the grid through 11 and 33 kilovolts (kV) systems (Zimbabwe Power Station, 2016). The research area was chosen because it is a coal-fired power station, which uses coal in power generation. Hence workers are exposed to coal dust, and the case study area was convenient for the researcher.

3.5 STUDY POPULATION

Bulawayo Power Station has a total of 450 workers, including office administration and power generation process staff. Workers in power-generation operations were 245, forming the total population from which the sample size was determined. Power-generation workers included plant operators, assistants, auxiliary operators, plant attendants, plant cleaners, water treatment operators, laboratory analysts, loss control personnel, attachés, postgraduate learners; apprentices and artisans in mechanical, electrical, civil, instrumentation and information technology. The study population members were selected because they are exposed to coal dust during their day-to-day operations in the power station.

A sample size of 152 was drawn from the 245 power station generation workers. The method of calculation used to derive the sample size is given in Equation 1, where *n* is the sample size, *N* is the population size, and *e* is the level of precision at ±5 percent and a confidence level of 95 percent.

$$n = \frac{N}{[1+N\,(e)^2]} \qquad \text{Equation 1}$$

A stratified random sampling strategy was employed, by which the study population were classified according to their departments or operations, and then random sampling was used to select the number of samples in each stratum.

Table 3.1: Distribution of respondents by work department

Area	Frequency (n)	Percent (%)
Operations	76	50
Maintenance	67	44.1
Loss Control	9	5.9
Total	**152**	**100**

The study population included workers working with and exposed to coal dust. These consisted of workers from power-generation operations, such as the coal plant, boiler house, turbine house, basement, water treatment and laboratory; plant maintenance departments such as electrical, mechanical, civil, instrumentation and information technology; contractors; and loss control departments (Table 3.1). Workers included in the study population had been working continuously in coal-dust environments for more than six months.

The study excluded all administrative office staff members from support services, including finance, administration, human resources, quality and risk, such as heads of section, managers, officers, clerks and office assistants. The study excluded these workers as they work mostly in offices, where they are not exposed to coal dust. The study also excluded contractors and temporary workers who had worked for less than six months within the power-generation operations.

3.6 DATA COLLECTION

The researcher collected primary data through the use of a structured interviewer-administered questionnaire. The questionnaire had three sections: socio-demographic data including age, gender, occupation and work experience; the respondents' knowledge about coal-dust and related health problems; and questions about attitudes and beliefs towards the adverse health effects of coal-dust (Appendix C).

A composite knowledge and attitude score was developed by scoring questions relating to knowledge and attitudes. A single point was awarded for each correct answer, and no point was awarded for an incorrect answer for both the single and multiple-choice questions (Nwankwo *et al*., 2018). Questions with a Likert scale were ranked such that stronger agreement with positive responses was given a high score with a single point separating each interval between ranks of one to five (Josh *et al*., 2015).

3.7 VALIDITY OF THE DATA

The researcher conducted a pilot study of fifteen respondents to pre-test the questionnaire, by correcting any inappropriate words, grammar and to evaluate the feasibility of the study. Words and phrases such as hypertension, COPD, pneumoconiosis, respiratory diseases, transmissible, heredity, treatable and preventable were changed to use simple and easy to understand ones. The pilot study respondents were not taking part in the survey and the results from the pilot study did not form part of the main reporting.

3.8 RELIABILITY

The researcher standardised the conditions under which the questionnaires were answered to improve the reliability of the study. Thus, the researcher interviewed the study participants at the beginning of their work shifts, before they started their daily work duties. Furthermore, the researcher ensured that there was no variation in asking the structured questions among the study participants, by having an average standard time for completing each questionnaire.

3.9 ETHICAL CONSIDERATIONS

Written permission was sought and obtained to undertake the study from the following institutions and committees:

- Zimbabwe Power Company, which is responsible for Bulawayo Power Station that employs the study participants (Appendix D)
- University of Johannesburg Higher Degrees Committee (Appendix E)
- University of Johannesburg Research and Ethics Committee (Appendix F)

The study participants were informed about the research study through a research information letter before they consented to participate in the survey. The research information letter also informed the study participants about their rights before, during and after the survey, such as confidentiality, withdrawal from the research at any time, and anonymity. The participants were expected to append their initials on the bottom right corner of each page of the research information letter to show that they had read and understood the study requirements.

The study participants' confidentiality was promoted through the removal or exclusion of their personal details, such as names, from the completed questionnaires. In addition, the names and any material that would identify the respondents would be excluded when publishing the research results, thereby promoting anonymity. The researcher informed the study participants about their protection against harm, as the study was undertaken in a manner that would not pose a potential and actual danger to the participants. As such, participants had the right to withdraw from the research study at any stage without any apprehensions. Refer to Appendix A and B for an information sheet and consent form.

3.10 DATA ANALYSIS

Data collected included socio-demographic information of the participants, such as age, gender, occupation, department and length of work; participants' knowledge about coal-dust health hazards; and their attitudes and beliefs towards adverse health effects of coal dust. The data were entered and analysed in the Statistical Package for the Social Sciences (SPSS) Version 25 and presented using Microsoft Excel.

The composite scores were calculated and converted to percentages for each respondent. Scores less than 50% implied that the respondent has "poor knowledge or attitude" while a score of more than 50% was categorised as "good knowledge or attitude", respectively. Categorical data were presented as frequency tables and inferential analysis was done at a bivariate level with Chi-square test. The level of statistical significance was set at $p = 0.05$.

CHAPTER 4: FINDINGS, ANALYSIS, INTERPRETATION AND DISCUSSION

4.1 INTRODUCTION

This chapter presents analyses, interprets, and discusses the research findings that were gathered through the use of questionnaires. The questionnaire collected data, which included socio-demographic characteristics, such as age, gender, department and length of work; respondent's knowledge about coal-dust health hazards; and their perceptions and attitudes towards adverse health effects of coal dust. The data were gathered to fulfil the aim of the study, which was to establish workers' perception of coal-dust exposure and health hazards. The data collected were captured and analysed at Statkon, using SPSS Version 25.

4.2 SOCIO-DEMOGRAPHIC CHARACTERISTICS OF RESPONDENTS

The socio-demographic characteristics of the respondents are presented in Table 4.1 and Table 4.2. The study recruited 152 participants, all of whom managed to complete the questionnaires, with 114 (75%) males, 37 (24.3%) females, and with gender information for one participant missing. Therefore, a 100 percent response rate was attained from the study.

4.2.1 AGE

Table 4.1 presents the age of the respondents. Results show that about half of the respondents (48.7%) interviewed were between the ages of 18 and 29 years, while slightly below a quarter were within the age category of 30 to 39. Thus, the majority of the respondents were in the age range of 18 to 39 years. This was consonant with another study conducted at coal-fired power station in India that had the majority of respondents in the age range 18 to 40 (Kumar *et al*., 2015).

Table 4.1: Age range for the respondents

Age range	Frequency (n)	Percent (%)
18 – 29	74	48.7
30 – 39	35	23.0
40 – 49	21	13.8
≥50	21	13.8
Missing	1	0.7
Total	**152**	**100**

4.2.2 LENGTH OF WORK

Table 4.2 shows the distribution of the years the respondents had been employed by the power station. Results showed that more than a quarter of the respondents (n=42) had been employed by the power station for less than a year. The greater proportion of the respondents had been employed for more than one year. Similar results were found in a study on safety practice and the knowledge of hazards among construction workers, were mostly workers who had more than a year working in a dusty work environment (Stella & Okeoghene, 2017).

Table 4.2: Distribution of the length of work (years) for the respondents

Length of work in years	Frequency (n)	Percent (%)
<1	42	27.6
1 – 9	60	39.5
10 – 19	28	18.4
≥20	19	12.5
Missing	3	2
Total	**152**	**100**

4.3 WORKERS' KNOWLEDGE OF COAL-DUST HEALTH HAZARDS

This section will cover the workers' knowledge of coal-dust health hazards. The questionnaire had multiple choice questions about the identification of coal health hazards, route of exposure, hazardous coal-dust concentration levels, and frequency and duration of exposure that could lead to the development of respiratory and breathing problems. Lastly it had questions on health problems associated with coal-dust exposure and control.

4.3.1 SOURCES OF COAL-DUST EXPOSURE

Table 4.3 shows the distribution of responses about coal-dust exposure from a variety of sources in the coal-fired power station. Results showed that the greater proportion of the respondents (n=123; 81%) were aware of the source of coal-dust exposure at the coal-fired power station, which were the coal plant, coal yard and boiler house. Sources of dust exposure were identified in a study on the risk perceived for dust and its impact. The study found that the majority of the respondents identified mine dumps as the source of coal dust, followed by sandblasting, coal yards and dry seasons (Wright *et al*., 2014).

Table 4.3: Responses on sources of coal-dust exposure

Sources	**Frequency (n)**	**Percent (%)**
Coal plant	83	54.6
Coal yard	26	17.1
Boiler house	14	9.2
Turbine house	8	5.3
Main gate	7	4.6
Basement	14	9.2
Total	**152**	**100**

4.3.2 COAL-DUST ROUTE OF EXPOSURE

Table 4.4 tabulates the responses of the employees regarding the route of exposure to coal dust. Results showed that most of the respondents (93.4%) were knowlegeable about the route of exposure to coal dust (inhalation), which may lead to respiratory complications. While 6.6% had poor knowledge, by responding that eating and skin contact were the route of exposure, which may lead to respiratory and breathing problems. A previous study on the knowledge regarding respiratory symptoms in Pakistan showed similar knowledge, as 85.2% of textile workers cited lungs as the organ affected by harmful effects of cotton dust when inhaled (Khoso & Nafee, 2015).

Table 4.4: Responses on route of exposure to coal-dust

Routes of Exposure	Frequency (n)	Percent (%)
Eating	4	2.6
Skin Contact	6	3.9
Breathing	142	93.4
Total	**152**	**100**

4.3.3 SAFE COAL-DUST CONCENTRATION LEVELS

Respondents were asked whether there are safe coal-dust concentration levels. A larger proportion of respondents (82.2%) affirmed that there were either no safe coal-dust concentration levels or were not sure. While a lesser proportion (17.8%) indicated that there were and at times safe coal-dust concentration levels. The implication of the result is that coal-dust concentration levels were not being monitored and workers are unaware of coal-dust concentration levels within the power station. A previous study in Namibia revealed that charcoal-dust levels were found to be much higher than the recommended OEL, and were associated with respiratory problems (Hamatui *et al*., 2016). The recommended OEL are considered safe dust concentration levels. Therefore, power stations are expected to conduct coal-dust sampling to establish concentration levels against the prescribed OEL (Mabanga, 2017). These OEL are to be benchmarked using international standards on coal-dust exposure (Zosky *et al*., 2016).

Table 4.5: Responses on safe coal-dust concentration levels

Coal-dust Levels	Frequency (n)	Percent (%)
Yes	17	11.2
No	96	63.2
Not sure	29	19.1
At times	10	6.6
Total	**152**	**100**

4.3.4 FREQUENCY AND DURATION OF COAL-DUST EXPOSURE

Table 4.6 shows that more than half of the respondents (57.9%) reported that continuous (repeated) exposure to coal-dust concentration levels could lead to the development of respiratory or breathing problems. More than a quarter reported *often* with just above a tenth reporting *once* and *five times*. This result was found to be similar to a previous study in South Africa that reported that continuous exposure to coal-dust was significantly associated with respiratory symptoms (Utembe *et al*., 2015).

Table 4.6: Responses on frequency of coal-dust exposure

Valid	Frequency (n)	Percent (%)
Once	14	9.2
Five times	4	2.6
Often	46	30.3
Continuous (repeated)	88	57.9
Total	**152**	**100**

Study participants were asked about the duration an employee can be exposed to coal-dust to develop respiratory or breathing problems. The majority of the respondents (48%) had the knowledge that an employee who is exposed to coal dust for more than a year can develop respiratory or breathing problems (Table 4.7). An interesting finding is that a quarter (25%) were of the opinion that an employee develops respiratory complications when exposed to coal dust for a day. Similar results were reported among gold miners where significantly higher proportions of respiratory conditions were found among respondents who had a cumulative exposure of 10 to 20 years, while those with less cumulative years reported lower proportions (Ayaaba *et al*., 2017). The development of respiratory problems is also determined by dust concentration levels, besides the frequency and the duration of exposure. Therefore, training and awareness are important through conducting safety talks on coal-dust exposure and the use of respiratory protective devices (Jasiulewicz-Kaczmarek *et al*., 2016).

Table 4.7: Responses on duration of coal-dust exposure

Duration	Frequency (n)	Percent (%)
Day	38	25
Week	14	9.2
Month	24	15.8
>1 Year	73	48
Missing	3	2
Total	**152**	**100**

4.3.5 HEALTH PROBLEMS CAUSED BY COAL-DUST EXPOSURE

Table 4.8 shows a tabulation of responses to health problems caused by coal-dust exposure. Results showed that, among the workers at the coal-fired power station, breathlessness is a major health outcome (74%) attributable to coal-dust exposure. The remaining quarter reported other health problems, such as tiredness (fatigue), headache and sore throat. Therefore, most of the respondents (n=113; 74%) were aware that breathlessness was the health problem caused by exposure to coal dust.

Table 4.8: Response to health problems caused by coal-dust exposure

Health problems	Frequency (n)	Percent (%)
Tiredness (fatigue)	9	5.9
Headache	5	3.3
Breathlessness	113	74.3
Sore throat	24	15.8
Missing	1	0.7
Total	**152**	**100**

A similar health problem of shortness of breath was reported as a symptom of occupational respiratory diseases (Shrivasta *et al*., 2018). These respiratory or breathing problems can be identified at early stages among workers, through medical screening and surveillance so as to institute control measures (Zosky *et al*., 2016). Therefore, power stations conduct wellness programmes to raise awareness and medical examinations for screening respiratory problems (Hughson *et al*., 2002).

4.3.6 PROTECTION AGAINST COAL-DUST EXPOSURE

More than half of the respondents (59.2%) reported that wearing a dust mask can protect a worker from coal-dust exposure. A quarter reported watering coal (dust suppression), while the rest reported worker's training (7.2%) and drinking milk (8.6%). The larger proportion of the respondents (n=128; 84%) had the knowledge of some of the ways workers can be protected against exposure to coal dust. This result was similar to a previous study among textile workers in Pakistan that said face masks were used as a measure against cotton dust (Khoso & Nafee, 2015).

Table 4.9: Responses to workers' protection against coal-dust exposure

Protection	Frequency (n)	Percent (%)
Drinking milk	13	8.6
Watering coal	38	25
Workers' training	11	7.2
Wearing dust masks	90	59.2
Total	**152**	**100**

4.4 WORKERS' PERCEPTIONS AND ATTITUDES TOWARDS ADVERSE HEALTH EFFECTS OF COAL DUST

This section covered workers' perceptions and attitudes towards adverse health effects of coal-dust exposure. Thus, the questionnaire had questions with a Likert scale in which respondents had to give their views by rating. Workers' perceptions were sought concerning exposure to coal dust, it being a major health hazard and the risk of developing respiratory or breathing problems, including tuberculosis. Regarding occupational respiratory or breathing conditions, workers' perceptions were sought concerning their transmission among workers through contact, transmission to their children and curability.

4.4.1 PERCEPTION OF POWER STATION WORKERS EXPOSED TO COAL DUST

The greater majority of the respondents agreed that power station workers were exposed to coal dust, while a few disagreed (36 times less than those who agreed). The respondents (94.7%) perceived that power station workers were exposed to coal dust while at work (Table 4.10). Similar findings were reported on a perception and attitude study towards work-related ill health, where 96.3% of quarry crushers reported that they were exposed to dust (Uwakwe *et al*., 2015)

Table 4.10: Perception of power station workers being exposed to coal-dust

Perception	Frequency (n)	Percent (%)
Strongly agree	97	63.8
Agree	47	30.9
Neither agree nor disagree	4	2.6
Disagree	4	2.6
Strongly disagree	0	0
Total	**152**	**100**

4.4.2 PERCEPTION OF COAL DUST AS A MAJOR HEALTH HAZARD

Table 4.11 shows a tabulation of the perception of workers at the Bulawayo power station regarding coal-dust as a major health hazard. Results showed that the majority of the respondents (67%) perceived coal-dust as a primary health hazard in the power station. These findings were consistent with a study on knowledge and practices related to occupational hazards that exposure to dust was viewed as a serious hazard, as reported by Ahmed and Newson-Smith (2010).

Table 4.11: Perception of coal-dust as a major health hazard

Perception	Frequency (n)	Percent (%)
Strongly agree	101	66.9
Agree	43	28.5
Neither agree nor disagree	5	3.3
Disagree	1	0.7
Strongly disagree	1	0.7
Missing	1	1.7
Total	**152**	**100**

4.4.3 PERCEPTION OF THE RISK OF DEVELOPING BREATHING PROBLEMS AND ITS ASSOCIATION WITH COAL DUST

Workers' opinion was sought on whether they were at risk of developing respiratory or breathing problems (Table 4.12). More than three-quarters of the respondents (76.3%) perceived that they were at risk of developing respiratory or breathing problems. Less than a quarter of the respondents were either neutral or in disagreement. Therefore, workers perceived that they were at risk of developing respiratory or breathing problems. A previous study among Kenyan community members had similar results that 80% perceived that pollution from industries posed a considerable risk to their health (Omanga *et al*., 2014).

Table 4.12: Perception of the risk of developing breathing problems

Perception	**Frequency (n)**	**Percent (%)**
Strongly agree	42	27.8
Agree	74	49
Neither agree nor disagree	24	15.9
Disagree	8	5.3
Strongly disagree	3	2
Missing	1	0.7
Total	**152**	**100**

Table 4.13 shows the perception of the workers in the Bulawayo Power Station to coal dust and associated breathing problems. Respondents who perceived that coal-dust exposure causes any breathing problems were 10 times more than those who perceived otherwise. Overall, the majority of the respondents (90.8%) believed that coal dust causes respiratory or breathing problems. Similar perceptions were reported by a study that focused on community members who in at close proximity to mine dumps. It was indicated that community members perceived that breathing in dust would cause health problems to both children and adults (Wright *et al*., 2014).

Table 4.13: Perception of coal dust causing any breathing problems

Perception	**Frequency (n)**	**Percent (%)**
Strongly agree	76	50.0
Agree	62	40.8
Neither agree nor disagree	12	7.9
Disagree	1	0.7
Strongly disagree	1	0.7
Total	**152**	**100**

4.4.4 PERCEPTION OF COAL-DUST EXPOSURE CAUSING TUBERCULOSIS

Almost half of the respondents (49%) perceived that exposure to coal dust causes tuberculosis. Slightly more than a quarter disagreed and a quarter of the respondents had a neutral perception about coal-dust exposure causing tuberculosis (Table 4.14). The majority of respondents perceived that coal-dust exposure causes tuberculosis. Misconceptions and negative attitudes regarding the causes of tuberculosis were reported in a previous study, which were in contrast to this study results. The study reported that tuberculosis was caused by germs, smoking, living conditions, cold, hard labour, poor nutrition and transmitted by air in different countries (Chang & Cataldo, 2014). The implementation of health promotion programmes such as putting up information, educational and communication (IEC) material on risk factors of respiratory problems including tuberculosis transmission plays a significant role in dispelling negative attitudes (Gyekye, 2006).

Table 4.14: Perception of coal-dust exposure causing tuberculosis

Perception	Frequency (n)	Percent (%)
Strongly agree	43	28.5
Agree	31	20.5
Neither agree nor disagree	38	25.2
Disagree	21	13.9
Strongly disagree	18	11.9
Missing	1	0.7
Total	**152**	**100**

4.4.5 PERCEPTION OF RISKS OF TRANSMISSION OF COAL-DUST INDUCED BREATHING PROBLEMS AMONG WORKERS THROUGH CONTACT

Table 4.15 shows the perception of risk of transmission of coal-induced breathing problems among workers through contact. Results indicated that the majority of the respondents (79%) disagreed that respiratory or breathing problems due to coal-dust exposure can be passed between workers through dermal contact.

Table 4.15: Perception of breathing problems caused by coal-dust exposure being passed from a worker to another through contact

Perception	**Frequency (n)**	**Percent (%)**
Strongly agree	6	4
Agree	6	4
Neither agree nor disagree	20	13.2
Disagree	38	25.2
Strongly disagree	81	53.6
Missing	1	0.7
Total	**152**	**100**

4.4.6 PERCEPTION OF RISKS OF TRANSMISSION OF COAL-DUST INDUCED BREATHING PROBLEMS FROM WORKERS TO THEIR CHILDREN

More than half of the respondents perceived that there was no risk of transmission of coal-induced respiratory or breathing problems from workers to their children; these were more than four times higher than those who perceived the risk and were neutral, respectively. Therefore, there was a negative attitude about occupational respiratory or breathing problems being passed from a worker to their children. A previous study reported that inhalation and accumulation of coal dust in lung tissues resulted in irreversible and non-infectious respiratory problems (Perret *et al*., 2017).

Table 4.16: Perception of breathing problems caused by coal-dust exposure being passed from a worker to their children

Perception	**Frequency (n)**	**Percent (%)**
Strongly agree	8	5.3
Agree	15	9.9
neither agree nor disagree	26	17.1
Disagree	37	24.3
Strongly disagree	66	43.4
Total	**152**	**100**

4.4.7 PERCEPTION OF COAL-DUST INDUCED BREATHING PROBLEMS BEING CURABLE THROUGH THE USE OF MEDICINE

Mixed responses were found as slightly more respondents (40.8%) perceived that coal-dust induced breathing problems were incurable through the use of medicines. More than a quarter of the respondents were neutral (26.3%) and more than a quarter (32.9%) perceived them as being curable. Therefore, respondents perceived that coal-dust induced breathing problems were incurable by using medicine. Similar results were reported in another study in which most respondents perceived that respiratory conditions would get progressively worse regardless of the treatment they received; thus, they were incurable (Sayiner *et al*., 2012).

Table 4.17: Perception about breathing problems caused by coal-dust exposure being curable through the use of medicine

Perception	**Frequency (n)**	**Percent (%)**
Strongly agree	16	10.5
Agree	34	22.4
Neither agree nor disagree	40	26.3
Disagree	35	23
Strongly disagree	27	17.8
Total	**152**	**100**

4.4.8 CAN WORKERS BE PROTECTED FROM COAL-DUST EXPOSURE?

The majority of respondents (77%) perceived that workers can be protected from exposure to coal dust, as compared to those who disagreed (12.5%). Therefore, respondents perceived that workers could be protected from coal-dust exposure. A study on perception and attitude towards work-related ill health had the same results, where quarry crushers (55.6%) perceived that ill health caused by dust exposure could be controlled (Uwakwe *et al*., 2015).

Table 4.18: Perception about workers' protection from coal-dust exposure

Perception	Frequency (n)	Percent (%)
Strongly agree	49	32.2
Agree	68	44.7
Neither agree nor disagree	16	10.5
Disagree	11	7.2
Strongly disagree	8	5.3
Total	**152**	**100**

4.5 RELATIONSHIP BETWEEN WORKERS' PERCEPTION ABOUT COAL-DUST EXPOSURE AND LENGTH OF WORK

A bivariate analysis was conducted to evaluate the relationship between workers' perception about coal-dust exposure and their length of work, using a Chi-square test. The results showed that there was a relationship between workers' perception of sources of coal-dust exposure and length of work ($p = 0.022$) (Table 4.19). Similar results were reported in a previous study which showed that age, socio-economic status and duration of work were significantly associated with having the knowledge and appropriate attitudes among textile workers in Pakistan (Khoso & Nafees, 2015).

There were no statistically significant differences between workers' length of work and their perceived risk of developing coal-dust induced respiratory or breathing problems, including tuberculosis; risk of transmission through contact between workers and to their children; being curable and being protected from dust exposure (Table 4.19). The result is consistent with a similar study conducted in Nigeria, which found that there was no statistically significant difference between workers who had worked for more than five years and their perception or knowledge of construction hazards (Stella & Okeoghene, 2017).

Table 4.19: Relationship between workers' perception about coal-dust exposure and length of work

Length of work	Power station workers exposed to coal dust			
(Years)	Agree	Neutral	Disagree	p-value
<1	37 (88.1)	1 (2.4)	4 (9.5)	0.022*
1 – 9	60 (100)	0(0)	0 (0)	
10 – 19	26 (92.9)	2 (7.1)	0 (0)	
≥20	18 (94.7)	1 (5.3)	0 (0)	

Length of work	Coal dust a major health hazard			
(Years)	Agree	Neutral	Disagree	p-value
<1	39 (95.1)	1 (2.4)	1 (2.4)	0.934
1 – 9	58 (96.7)	1 (1.7)	1 (1.7)	
10 – 19	27 (96.4)	1 (3.6)	0 (0)	
≥20	18 (94.7)	1 (5.3)	0 (0)	

Length of work	Risk of developing breathing problems			
(Years)	Agree	Neutral	Disagree	p-value
<1	27 (64.3)	10 (23.8)	5 (11.9)	0.487
1 – 9	47 (78.3)	9 (15)	4 (6.7)	
10 – 19	24 (85.7)	3 (10.7)	1 (3.6)	
≥20	15 (83.3)	2 (11.1)	1 (5.6)	

Length of Work	Coal-dust exposure causes tuberculosis			
(Years)	Agree	Neutral	Disagree	p-value
<1	22 (52.4)	14 (33.3)	6 (14.3)	0.177
1 – 9	26 (44.1)	14 (23.7)	19 (32.2)	
10 – 19	13 (46.4)	8 (28.6)	7 (25)	
≥20	11 (57.9)	1 (5.3)	7 (36.8)	

Length of Work	Breathing problems be passed from a worker to another through contact			
(Years)	Agree	Neutral	Disagree	p-value
<1	5 (11.9)	9 (21.4)	28 (66.7)	0.134
1 – 9	3 (5)	5 (8.3)	52 (86.7)	
10 – 19	1 (3.6)	2 (7.1)	25 (89.3)	
≥20	3 (16.7)	2 (11.1)	13 (72.2)	

Length of work	Breathing problems be passed from a worker to their children			
(Years)	Agree	Neutral	Disagree	p-value
<1	8 (19)	9 (21.4)	25 (59.5)	0.630
1 – 9	7 (11.7)	11 (18.3)	42 (70)	
10 – 19	3 (10.7)	3 (10.7)	22 (78.6)	
≥20	4 (21.1)	2 (10.5)	13 (68.4)	

Length of work	Breathing problems caused by coal dust curable through use of medicine			
(Years)	Agree	Neutral	Disagree	p-value
<1	13 (31)	16 (38.1)	13 (31)	0.430
1 – 9	21 (35)	14 (23.3)	25 (41.7)	
10 – 19	8 (28.6)	5 (17.9)	15 (53.6)	
≥20	6 (31.6)	4 (21.1)	9 (47.4)	

Length of Work	Workers can they be protected from coal-dust exposure			
(Years)	Agree	Neutral	Disagree	p-value
<1	33 (78.6)	3 (7.1)	6 (14.3)	0.143
1 – 9	50 (83.3)	4 (6.7)	6 (10)	
10 – 19	16 (57.1)	7 (25)	5 (17.9)	
≥20	15 (78.9)	2 (10.5)	2 (10.5)	

CHAPTER 5: SUMMARY AND CONCLUSIONS

5.1 INTRODUCTION

The previous chapter gave a detailed outlook of the results and findings of the study. This chapter presents a summary of key findings, which are based on the study objectives, and gives a conclusion. In addition, recommendations are given to address some of the study findings. The study limitations are also highlighted and proposed future studies are stated.

5.2 SUMMARY

The results showed that more than three quarters of the respondents (81%) were aware of the source of coal-dust exposure at the coal-fired power station, which were the coal plant, coal yard and boiler house. An awareness of breathing or inhalation as a route of exposure to coal dust was reported by the majority of respondents (93.4%). Most of the respondents (82.2%) were unaware of safe coal-dust concentration levels. More than half of the respondents (57.9%) reported that continuous exposure to coal-dust concentration levels and for more than a year (48%) could lead to the development of respiratory or breathing problems. The major health outcome that was reported among workers (74%) attributable to coal-dust exposure was breathlessness. The larger proportion of the respondents (84%) reported that wearing dust masks and watering coal (dust suppression) were ways to protect against exposure to coal dust.

Regarding perception and attitudes, 94.7% of respondents, reported that power station workers were exposed to coal dust. It was the primary health hazard (67%) and they were at risk of developing respiratory problems (76.3%). Just under half (49%) agreed that coal-dust exposure causes tuberculosis. Above three quarters (79%) and more than half (67.8%) of respondents did not perceive the risk of transmission of coal-induced breathing problems between workers and to their children, respectively. Less than half (40.8%) of respondents reported that coal-induced breathing problems were incurable through the use of medicine. More than three-quarters of the respondents (77%) perceived that workers can be protected from coal-dust exposure. There was no significant relationship found between workers' perception of coal-dust exposure and their length of work.

5.3 CONCLUSION

Workers demonstrated overall good knowledge about coal-dust health hazards. Although, varied knowledge was seen with some of the risk factors that could lead to the development of respiratory or breathing problems, such as safe coal-dust concentration levels. They perceived that coal-dust was a major health hazard they were exposed to, at risk of developing respiratory problems and can be protected against coal-dust exposure. This perception and attitude were the same among workers regardless of their length of work at the power station. Therefore, workers may adopt healthy behaviours and safe practices to reduce exposure to coal-dust.

5.4 RECOMMENDATIONS

The researcher proposes the following recommendations to address the workers' perception, attitude and knowledge about exposure to coal dust; and overall management exposure to coal dust in coal-fired power stations:

- Development and implementation of workplace policies and procedures that promote workers to adopt healthy behaviours which include their participation in the development of coal-dust control mechanisms such as type of dust masks and reporting of exposure to coal-dust at their respective work stations;
- Conducting workplace health promotion programme such as safety toolbox talks; induction and refresher training; awareness campaigns; displaying Information, Education and Communication (IEC) materials and regulatory notices on coal-dust risk factors, symptoms and management of respiratory diseases to reinforce healthy behaviours and safe practices;
- Enactment of occupational safety and health laws which safeguard and promote workers' rights and enable them to adopt healthy practices especially those exposed to coal-dust;
- Amendment of occupational safety and health laws to include mandatory periodic dust sampling of all workplace with dust exposure and the

development of OEL values that are benchmarked with international standards;

- Provision of occupational health services that will record, monitor, investigate and manage suspected occupational respiratory conditions and provide medical surveillance for coal-fired power station workers.

5.5 LIMITATIONS AND FUTURE RESEARCH

This study and the literature review revealed a number of limitations. The literature review revealed that there were no similar studies on the workers' perception and attitudes about coal-dust exposure. The study limitations were the exclusion of participants' level of education and socio-economic status as it may influence perception; inclusion of their respiratory health would have added value; and the perception of occupational safety and health standards at the coal-fired power station. The Cronbach alpha (α) was not calculated after the pilot study to validate the questionnaire. Therefore, the researcher recommended the following future studies:

- Occupational exposure to respirable coal-dust and respiratory diseases among coal-fired power station workers
- Evaluate the relationship between coal-dust exposure and development of tuberculosis
- Evaluation of knowledge, attitude and perception of occupational safety and health at a coal-fired power station
- Perception of the effectiveness of coal-dust control measures at a coal-fired power station.

REFERENCES

Affolter, R. H., Hatch, J. R. 2015. Geologic Overview. Available from: http://www.usg.gov//pp/p1625d/chapter_C_pdf [Accessed 29 August 2018]

Ahmed, H. O., and Newson-Smith, M. S. 2010. Knowledge and practices related to hazards among cement workers in United Arab Emirates, *Journal Egypt Public Health Association*, 85(3-4): 149 - 167

Alif, S. M., Dharmage, S. C., Bowatte, G., Karahalios, A., Benke, G., Dennekamp, M., Mehta, A. J., Miedinger, D., Kunzli, N., Probst-Hensch, N., and Matheson, M. C. 2016. Occupational exposure and risk of chronic obstructive pulmonary disease: a systematic review and meta-analysis, *Expert Review of Respiratory Medicine*, Taylor & Francis

Aluko, O. O., Adebayo, A. E., Adebisi, T. F., Ewegbemi, M. K., Abidoye, A. T., and Popoola, B. F. 2016. Knowledge, attitudes and perceptions of occupational hazards and safety practices in Nigeria health care workers, *BMC Respiratory Notes*, 9:71

Ashraf, S., Zaman, M., and Ashraf, A. 2005. Knowledge, Attitude, Perception (KAP) of coal mine workers of Shangla District regarding occupational safety, *Pakistan Journal of Chest Medicine*, 11(1): 11 – 17

American Conference of Government Industrial Hygienists. 2014. Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices. Cincinnati, OH: American Conference of Governmental Industrial Hygienists

Ayaaba, E., Liu, Y., Li, Y., Han, L., Yedu, Q. D., and Chunhui, N. 2017. Measures to Control the Prevalence of Pneumoconiosis in Coal Mining: A Review of the Literature, *International Journal of Translational Medical Research and Public Health*, 1(1):4-13

Ayaaba, E., Li, Y., Yuan, J., and Ni, C. 2017. Occupational respiratory diseases of miners from two gold mines in Ghana, *International Journal of Environmental Research and Public Health*, 14, 337

Beer, C., Kolstad, H. A., Sondergaard, K., Bendstup, E., Heederik, D., Olsen, K. E., Omland, O., Petsouk, E., Sigsgaard, T., Sherson, D. L and Schlunssen, V. 2016. A systematic review of occupational exposure to coal dust and the risk of interstitial lung disease, *European Clinical Respiratory Journal*, 4(1)

Cambridge English Dictionary. 2018. Cambridge University Press. Available from http://dictionary.cambridge.org/dictionary/english/knowlede [Accessed on 13 December 2018]

Chang, S-H., and Cataldo, J.K. 2014. A systematic review of global cultural variations in knowledge, attitudes and health responses to tuberculosis stigma, *International Journal on Tuberculosis Lung Diseases*, 18(2): 168 – 173

Cherry, K. 2018. Attitudes and Behavior in Psychology, Medically reviewed by Steven Gans MD. Available from https://www.verywellmind.com/attitudes-how-they-form-change-shape-behavior-2795897 [Accessed on 11 December 2018]

Cooper, D. 2001. Improving Safety Culture, a Practical Guide, British Library Catalogue, London

Erol, I., Aydin, H., Didari, V., and Ural, S. 2013. Pneumoconiosis and quartz content of respirable dusts in the coal mines in Zonguldak, Turkey, *International Journal of Coal Geology*, 116 – 117: 26 – 35

Gwimbi, P. 2017. Monitoring SO2 emission trends and residents' perceived health risks from PGM smelting at Selous Metallurgical Complex in Zimbabwe, *International Journal for Equity in Health*, 16:200

Gyekye, S. A. 2006. Workers' perceptions of workplace safety: An African perspective, *International Journal of Occupational Safety and Ergonomics*, 12(1): 31 – 42

Hamatui, N., Naidoo, R. N., and Kgabi, N. 2016. Respiratory health effects of occupational exposure to charcoal dust in Namibia, *International Journal of Occupational and Environmental Health*, 22(3):240 - 248

Hatfield, G. 2001. Perception: History of the concept, International Encyclopaedia of the Social and Behavioral Science, Science Direct: Elsevier, 11202 - 11205

Health and Safety Executive. 2010. How best to communicate health and safety messages to young learners in vocational education and training. National Centre for Social Research, London

Health and Safety Executive. 2014. Literature Review: Understanding how to improve the management of exposure to wood dust amongst construction sub-contractors and manufacturing SMEs. Health and Safety Laboratory, Derbyshire

Health and Safety Executive. 2016. Silicosis and Coal Workers' Pneumoconiosis. Available from: http://www.hse.gov.uk/statistics/ [Accessed 8 March 2018]

Hegde, R. K. 2015. Power Plant Engineering, Pearson, India

Iashin, S. 2018. Coal-fired power plant (Principle, Diagram and Environmental Impact). Available from: http://www.tpo-ee.com/ [Accessed 28 August 2018]

Hughson, G. W., Mulholland, K. E., and Cowie, H. A. 2002. Behavioural studies of people's attitudes to wearing hearing protection and how these might be changed,

Institute of Occupational Medicine for the Health and Safety Executive, United Kingdom
Ivers, R., Senserrick, T., and Boufous, S. 2009. Novice drivers’ risky behaviour, risk perception and crash risk: Findings from the Drive Study, *American Journal of Public Health*, 99(9): 1638-1644.
Jasiulewicz-Kaczmarek, M., Szwedzka, K., and Szczuka, M. 2015. Behaviour Based Intervention of Occupational Safety – Case Study, *Procedia Manufacturing*, 3: 4876-4883
Jerie, S. 2012. Occupational health and safety problems among workers in the wood processing industries in Mutare, Zimbabwe, *Journal of Emerging Trends in Economics and Management Sciences*, 3(3): 278 - 285
Josh, A., Kale, S., Chandel, S and Pal, D. K. 2015. Likert Scale: Explored and Explained, *British Journal of Applied Science and Technology*, 7(4): 396 - 403
Khoso, A., and Nafees, A. 2015. Knowledge, attitude and practices regarding respiratory symptoms among textile workers of Karachi, Pakistan: a cross-sectional survey, *The Journal of the Pakistan Medical Association*, 65(1): 17 - 23.
Kraushaan, J., Ristinen, R. 2015. Energy and the Environment, Second Edition, Hoboken New Jersey: John Wiley and Sons, pp 50
Kumar, A., Shrivastara, S. M., Jain, N. K and Patel, P. 2015. Identification of Occupational Diseases, Health Risk, Hazards and injuries among the workers engaged in Thermal Power Plant*, International Journal of Research in Engineering and Technology*, 4(1): 149 - 156
Kumar, T. 2016. Overview of Thermal Power Plant, *International Advanced Research Journal in Science Engineering and Technology*, 3(7): 264 - 267
Laney, A. and Weissman, D. 2014. ‘Respiratory diseases caused by coal mine dust’, *Journal of Occupational and Environmental Medicine*, (56): 18 – 22
Mabanga, S. N. K. 2017. Respirable dust and quartz exposure at coal power station in Mpumalanga Province during 2012 – 2015. DBL thesis. University of Witwatersrand, Johannesburg
Marambanyika, T. and Sadrake, F. D. 2013. Workers’ perceptions and awareness of occupational health and safety legislations in the food manufacturing industry in Zimbabwe, *The Dyke*, 7(2):43 - 58
Martyka, J., and Lebecki, K. 2014. Safety culture in high-risk industries, *International Journal of Occupational Safety and Ergonomics*, 20(4): 561 - 572

Miller, A. L., Murphy, N. C., Bayman, S. J., Briggs, Z. P., Kilpatrick, A. D., Quinn, C. A., Wadas, M. R., Cauda, E. G. & Griffiths, P. R. 2015. Evaluation of Diffuse Reflection Infrared Spectrometry for End-of-Shift Measurement of α-quartz in Coal Dust Samples. *Journal of Occupational and Environmental Hygiene*, 00-0

Mo, J., Wang, L., Au, W., and Su, M. 2014. Prevalence of coal workers' pneumoconiosis in China: a systematic analysis of 2001-2011 studies, *International Journal of Hygiene and Environmental Health*, 217(1): 46 – 51

Mobaraki, A., Mirzaei, R., and Ansari, H. 2017. A survey of Health, Safety and Environment Management and Safety Climate, *Engineering, Technology and Applied Science Research*, 7(1): 1334 - 1337

Mojapelo, J., Mafini, C., and Dhurup, M. 2016. Employee perception of occupational health and safety standards in the steel industry, *International Journal of Social Science and Humanity*, 8(2): 106 – 121

Naidoo, J., and Wills, J. 2009. Foundations for Health Promotion, Third Edition. Bristol & London: Bailliere Tindall, Elsevier

National Institute of Occupational Safety and Health, 2015. Occupational exposure to respirable coal mine dust. Available from: http://www.cdc.gov/niosh/docs/95-106/pdfs/95-106.pdf. [Accessed 12 April 2018]

Nwankwo, O. N. O., Mokogwu, N., Agboghoroma, O., Ahmed, F. O., and Mortimer, K. 2018. Knowledge, attitudes and beliefs about health hazards of biomass smoke exposure amongst commercial food vendors in Nigeria. Available form: http://doi.org/10.1371/journal.pone.0191458 [Accessed 25 November 2018]

Omanga, E., Ulmer, L., Berhane, Z., and Gatari, M. 2014. Industrial air pollution in rural Kenya: community awareness, risk perception and associations between risk variables. *BMC Public Health*, 14:377.

Oluwafemi, F. S., Abiola, A., Akingbade, A. M., Faeji, C. O., and Oni, I. O. 2017. Knowledge of Occupational Hazards, Attitude and Practice of Occupational Safety Measures Among Construction Workers in Different Building Sites Located in Ibeju-Lekki Local Government Area of Lagos State, Nigeria. *Online Journal Health and Allied Sciences*, 16(4):10.

O'Toole, M., and Nalbone, D. P. 2011. Safety Perception Surveys, What to Ask, How to Analyze, *Professional Safety*: 58 - 62

Perret, J. L., Plush, B. Lachapelle, P. Hinks, T. S. C. Walter, C. Clarke, P., Irving, L. Brady, Dharmage, P. S., and Stewart, A. 2017. Coal mine dust lung disease in the modern era, *Respirology*, 22, 662 - 670.

Rey, C. H. T., Ayala, L. B., Torres, G. M., Restrep, H. G and Uribe, M. V. 2015. Underground Coal Mining: Relationship between Coal Dust Levels and Pneumoconiosis in Two Regions, *Bio Med Research International Volume*, Hindawi Publishing Corporation, Article ID 64787

Riazi, M. R., Gupta, R. 2015. Coal Production and Processing Technology, CRC Press Books

Sarkar, D. 2015. Thermal Power Plant: Design and Operation, Elsevier Science

Sayinera, A., Alzaabib, A., Obeidat, N., M., Nejjarid, C,. Bejie, M., Uzaslanf, E., Nafti, S., Khanh, J. K., Tageldini, A. M., Idrees, M. A., Rashidk, N., and El Hasnaou, A. 2012. Attitudes and Beliefs about Chronic Obstructive Pulmonary Diseases, *Respiratory Medicine*, 106(2): 60 – 74

Scriven, A. 2010. Promoting Health: A Practical Guide, Sixth Edition. Edinburg: Elsevier

Shrivastava, A., Tomar, S. P., and Patel, M. 2018. Prevalence of symptoms of occupational lung diseases in marble cutting workers, *International Journal of Community Medicine and Public Health*, 5(8): 3368 - 3371

Speight, J. G. 2016. The Chemistry and Technology of Coal, Third Edition. CRC Press Books.

Stella, R., and Okeoghene, E. A. 2017. “Safety Practices and Knowledge of Construction Workers on Hazards Associated with Working on Road Construction Sites in Egor Local Government Area of Edo State.” *World Journal of Preventive Medicine*, 5(1): 19-25

Tobor-Osadnik, K., Wyganowska, M., and Manowska, A. 2017. Employee Attitude to Work Safety in Poland’s Coal Mining Companies, *The Journal of Southern African Institute of Mining and Metallurgy*, 117: 41 - 46

Utembe, W., Faustman, E. M., Matatiele, P., and Gulumian, M. 2015. Hazards identified and the need for health risk assessment in the South African mining industry, *Human and Experimental Toxicology,* 34(12):1212–1221

Uwakwe, K. A., Agu, A. P., Ogbonnay, L. U., Nwonwu, E. U., Aguwa, E. N., and Duru, C. B. 2015. Perception and Attitude towards Work Related Ill-health and use of Dust Mask among Crushers of Selected Quarry (Crushed Stone) Industry in Ebonyi State:

Effect of Health Education, *Journal of Community Medicine and Primary Health Care*, 27 (2): 93-103

Varona, M., Ibanez-Pinilla, M., Briceno, L., Groot, H., Narvaez, D., Palma, M., Herrera, D., Morga, G., and Torres, C. 2018. Evaluation of the exposure to coal dust and prevalence of pneumoconiosis in underground mining in three Colombian departments, *Biomedica*, 38(4)

World Coal Association. 2018. Uses of Coal. Available from: http://www.worldcoal.org/local/uses-coal [Accessed 17 August 2018]

World Energy Council. 2013. World Energy Resources 2013 Survey. London: World Energy Council

World Health Organization. 2017. Preventing non-communicable diseases (NCDs) by reducing environmental risk factors. Geneva: World Health Organization

Wright, C. Y., Matooane, M., Oosthuizen, M. A., and Phala, N. 2014. Risk perceptions of dust and its impacts among communities living in a mining area of the Witwatersrand, South Africa, *Clean Air Journal*, 24(1): 22 - 27

Xia, Y. Liu, J. Shi, T. Xiang, H. Bi, Y. 2014. 'Prevalence of Pneumoconiosis in Hubei China from 2008 to 2013', *International Journal of Environmental Respiratory Public Health*, 11(9): 8612 – 8621

Zhang, J., Chan, N., Fu, G., Yan, M., and Kim, Y-C. 2016. 'The Safety Attitudes of Senior Manager in Chinese Coal Industry', *International Journal of Environmental Research and Public Health*, 13, 1147

Zimbabwe Annual Statistical Report. 2009 - 2013. National Social Security Authority, Causeway, Harare

Zimbabwe National Statistics Agency. 2014. Labour Force Survey, Harare: Government Printers, p 57.

Zimbabwe Power Company. 2016. Annual Report [Online] Available from: http://www.zpc.co.zw/data/media/00000050/ANNUAL-REPORT-PAGES-CURVES-PDF Accessed on: 28 March 2018

Zosky, G. R., Hoy, R. F., Silverstone, E. J., Brims, F. J., Miles, S., Johnson, A. R., Gibson, P. G., and Yates, D. H. 2016. Coal Workers' Pneumoconiosis: An Australian perspective, *The Medical Journal of Australia*, 204(11): 414 – 418

APPENDICES

Appendix A

UNIVERSITY OF JOHANNESBURG

DEPARTMENT OF ENVIRONMENTAL HEALTH
RESEARCH STUDY INFORMATION LETTER

4 June 2018

Good Day

My name is Lentsoe Noko. **I WOULD LIKE TO INVITE YOU TO PARTICIPATE** in a research study on Workers' Perception and Attitude about Coal-dust exposure and Health Hazards: Case of Bulawayo Power Station, Zimbabwe

Before you decide on whether to participate, I would like to explain to you why the research is being done and what it will involve for you. **I will go through the information letter with you and answer any questions you have.** This should take about 10 to 20 minutes. The study is part of a research project being completed as a requirement for a Master of Public Health Degree in Environmental Health through the University of Johannesburg.

THE PURPOSE OF THIS STUDY is to understand the workers' awareness and views of coal-dust exposure at a coal-fired power station.

Below, I have compiled a set of questions and answers that I believe will assist you in understanding the relevant details of participation in this research study. Please read through these. If you have any further questions, I will be happy to answer them for you.

DO I HAVE TO TAKE PART? No, you don't have to. It is up to you to decide to participate in the study. I will describe the study and go through this information sheet. If you agree to take part, I will then ask you to sign a consent form.

WHAT EXACTLY WILL I BE EXPECTED TO DO IF I AGREE TO PARTICIPATE? To answer questions on workers' age, gender/ sex, length of work, occupation, knowledge and views about coal-dust exposure and the health problems associated with coal-dust exposure.

WHAT WILL HAPPEN IF I WANT TO WITHDRAW FROM THE STUDY? If you decide to participate, you are free to change your approval at any time without giving a reason and without any effects. If you wish to change your approval, you should inform me as soon as possible.

Participant's Initials: _____

IF I CHOOSE TO PARTICIPATE, WILL THERE BE ANY EXPENSES FOR ME, OR PAYMENT DUE TO ME: You will not be paid to participate in this study, and you will not bear any expenses.

RISKS INVOLVED IN PARTICIPATION: There are no anticipated risks.

WILL MY PARTICIPATION IN THIS STUDY BE KEPT CONFIDENTIAL? Yes. Names on the questionnaire/data sheet will be removed once information is being studied. All data and back-ups thereof will be kept in a password protected folders and locked away as applicable. Only I or my research supervisor will be authorised to use and release your information without any personal identity/ name in connection with this research study. Any other person wishing to work with you will remove your identity/ name in the information as part of the research process (e.g. an independent data coder) will be required to sign agreeing to keep the information private/ secret before being allowed to do so.

WILL MY TAKING PART IN THIS STUDY BE ANONYMOUS? Yes. Anonymous means that your personal details will not be recorded anywhere by me. As a result, it will not be possible for me or anyone else to identify your responses once these have been submitted.

WHAT WILL HAPPEN TO THE RESULTS OF THE RESEARCH STUDY? The results will be written in a study report that will be marked for purposes of higher education. In some cases, results may also be released for the public with an interest of the subject. Your identity/ name will remain unknown and kept private in any the documents, reports or releases. You will be allowed to have the study result if you would like, by contacting me.

WHO IS ORGANISING AND FUNDING THE STUDY? The study is being organised by me, under the guidance of my research supervisor at the Department of Environmental Health at the University of Johannesburg. This study has not received any funding.

WHO HAS REVIEWED AND APPROVED THIS STUDY? Before this study was allowed to start, it was assessed to make changes if they were any. This review was done first by the Department of Environmental Health, and then secondly by the Faculty of Health Sciences Research Ethics Committee at the University of Johannesburg. In both cases, the study was approved.

WHAT IF THERE IS A PROBLEM? If you have any concerns or complaints about this research study, the way it is being done or possibility of harm and gain, you should ask me. You should contact me at any time if you feel you have any concerns about being a part of this study. My contact details are:

Lentsoe Noko

You may also contact my research supervisor:
Mrs Martha Chadyiwa
mchadyiwa@uj.ac.za

If you feel that any questions or complaints regarding your participation in this study have not been dealt with adequately, you may contact the Chairperson of the Faculty of Health Sciences Research Ethics Committee at the University of Johannesburg:

Prof. Christopher Stein
Tel: 011 559-6564
Email: cstein@uj.ac.za

Participant's Initials: _____

FURTHER INFORMATION AND CONTACT DETAILS: Should you wish to have more specific information about this research project information, have any questions, concerns or complaints about this research study, its procedures, risks and benefits, you should communicate with me using any of the contact details given above.

Researcher:

Lentsoe Noko

Participant's Initials: _____

Appendix B

UNIVERSITY OF JOHANNESBURG

DEPARTMENT OF ENVIRONMENTAL HEALTH
RESEARCH CONSENT FORM

Workers' Perception and Attitude about Coal-dust exposure and Health Hazards, Case of Bulawayo Power Station, Zimbabwe

Please initial each box below:

☐ I confirm that I have read and understood the information letter dated 4 June 2018 for the above study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily.

☐ I understand that my participation is voluntary and that I am free to withdraw from this study at any time without giving any reason and without any consequences to me.

☐ I agree to take part in the above study.

______________________	______________________	________________
Name of Participant	Signature of Participant	Date

______________________	______________________	________________
Name of Researcher	Signature of Researcher	Date

Appendix C

QUESTIONNAIRE

1. Socio- demographic Information :

   a. Age in years: 18 – 29: ☐ 30 – 39: ☐
      40 – 49: ☐ ≥50: ☐

   b. Gender: Male: ☐ Female: ☐

   c. Occupation/ Department:______________________

   d. Length of Work in years: <1: ☐ 1-9: ☐
      10 – 19: ☐ ≥20: ☐

2. Respondents' knowledge about coal dust health hazards:

   a. Which department/ activities are sources of coal-dust exposure?
      Coal Plant: ____ Coal Yard: ___ Boiler House: ____
      Turbine House: _____ Main Gate: _____
      Basement: _____ Maintenance Workshop: _____

   b. How does coal dust get into an employee (route of exposure) and result in breathing problems?
      Eating: ___ Skin Contact: ___ Breathing: ___ Skin Breaking: ___

   c. Are there coal dust concentration levels which are regarded safe to human health?
      Yes: ___ No: ___ Not Sure: ___ At times: ___

   d. How often (frequent) can an employee be exposed to coal dust to develop breathing problems?
      Once: ___ 5 Times: ___ Often: ___ Continuous: ___

   e. How long (duration) can an employee be exposed to coal dust to develop breathing problems?
      Day: ___ Week: ___ Month: ___ >1 Year: ___

   f. What are the health problems that are caused by coal-dust exposure?
      Tiredness: ___ Headache: ___
      Breathlessness: ___ Sore throat: ___

g. What are some of the ways in which workers can be protected against coal-dust exposure?
   Drinking Milk: ___ Watering coal: __
   Workers Training: ___ Wearing Dusk Masks: ___

3. Questions about attitudes and beliefs towards adverse health effects of coal dust:

Responses may be: Strongly Disagree 1; Disagree 2; Neither Agree nor Disagree 3; Agree 4 and Strongly Agree

Are power station workers exposed to coal dust	1	2	3	4	5
Is coal dust a major health hazard	1	2	3	4	5
Are you at risk of developing breathing problems	1	2	3	4	5
Does coal-dust exposure cause any breathing problems	1	2	3	4	5
Does smoking cause breathing problems	1	2	3	4	5
Does coal-dust exposure cause Tuberculosis	1	2	3	4	5
Can breathing problems caused by coal-dust exposure be passed from a worker to another through contact	1	2	3	4	5
Can breathing problems caused by coal-dust exposure be passed from a worker to their children	1	2	3	4	5
Are breathing problems caused by coal-dust exposure curable through the use of medicine	1	2	3	4	5
Can workers be protected from coal-dust exposure that can lead to the development of breathing problems	1	2	3	4	5